United States Environmental Protection Agency
Region X
1200 Sixth Avenue
Seattle, Washington 98101

U.S. Department of Energy
Hanford Site - 100 Area
Benton County, Washington

Amended Record of Decision
Decision Summary and Responsiveness Summary

October 1999

INTERIM REMEDIAL ACTION RECORD OF DECISION AMENDMENT

DECLARATION

SITE NAME AND LOCATION

USDOE Hanford 100 Area EPA ID# WA3890090076
100-HR-3 Operable Unit
Hanford Site
Benton County, Washington

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) Amendment revises the selected interim remedial action for a portion of the U.S. Department of Energy (DOE) Hanford 100 Area, Hanford Site, Benton County, Washington. This action was chosen in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986*, and to the extent practicable, the *National Oil and Hazardous Substances Pollution Contingency Plan*. This ROD Amendment is based on the Administrative Record for the 100-HR-3 Operable Unit of the Hanford Site.

The Washington State Department of Ecology (Ecology) concurs with the selected remedy presented in this ROD Amendment.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the chromium contamination in the groundwater associated with the 100-HR-3 Operable Unit, if not addressed by implementing the response actions selected in this ROD Amendment, may present an imminent and substantial endangerment to the public health, welfare, or the environment.

DESCRIPTION OF THE AMENDMENT TO THE SELECTED REMEDY

In April 1996, an Interim Remedial Action ROD for the 100-HR-3 Operable Unit was signed by the U.S. Environmental Protection Agency (EPA), Ecology, and DOE (the Tri-Parties) directing removal of hexavalent chromium contamination from the groundwater at the 100-H and 100-D-DR reactor areas using a pump and treat system (known as the 100-D pump and treat system). During pore water sampling along the Columbia River, another plume of hexavalent chromium contamination was discovered southwest of the current 100-D pump and treat system. The extent of this plume was subsequently delineated through the installation of groundwater monitoring wells and was determined not captured by the 100-HR-3 Operable Unit pump and treat system.

This ROD Amendment alters the selected remedy action specified in the Interim Remedial Action ROD for the 100-HR-3 Operable Unit by deploying a new innovative technology (In Situ Redox Manipulation [ISRM]) for remediation of this recently characterized hexavalent chromium plume in the 100-D Area. The technology involves creating a permeable groundwater treatment barrier that reduces the mobility and toxicity of chromium in groundwater. A compliance monitoring plan will be developed in the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) to assess barrier performance. If barrier breakthrough is identified, Ecology and EPA will determine alternative action to be taken. Groundwater remediation by pump and treat will continue at the two other areas of the 100-HR-3 Operable Unit, as described in the 1996 Interim Remedial Action ROD.

STATUTORY DETERMINATIONS

Deployment of the ISRM technology at the recently characterized chromium plume in the 100-D Area (100-HR-3 Operable Unit) is consistent with the remedial action objectives identified in the 1996 Interim Remedial Action ROD. This alternative is believed to provide the best trade-offs among alternatives with respect to the CERCLA evaluation criteria.

Because this remedy may result in hazardous substances remaining onsite above levels that allow for unlimited use, a review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within 5 years after the commencement of the remedial action. This is an Interim Action ROD; therefore, review of this site and this remedy will be ongoing as the Tri-Parties continue to develop final remedial measures for the 100 Area National Priorities List site.

Protection of Human Health and the Environment

Ecology and EPA believe that the amended interim remedy (ISRM) is protective of human health and the environment. Treatability studies have demonstrated that this technology is effective with minimal risk to workers. Site institutional controls will continue during the interim remedial action period to limit human access to the groundwater. Ecological risk will be addressed by the amended interim action by reducing concentrations of chromium to ambient water quality standards within the river-bottom substrate.

Compliance with ARARs

The ISRM technology complies with federal and state requirements that are applicable, relevant, and appropriate. Although the ISRM technology involves injecting chemicals into the groundwater, these chemicals will not result in exceeding the primary drinking water standards, nor will they adversely affect the beneficial uses of the groundwater.

Cost Effectiveness

The Tri-Parties have determined that the selected remedy in this ROD Amendment is cost-effective, with costs that are proportional to the overall effectiveness.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The amended interim action would use permanent solutions to the maximum extent practicable and is an innovative technology.

Preference for Treatment as a Principal Element

Because the amended interim action would treat chromium contamination in the groundwater, this remedy would meet the statutory preference for the use as a remedy that involves treatment as a principal element.

Signature sheet for the Record of Decision for the U.S. Department of Energy Hanford 100-HR-3 Operable Unit interim remedial action between the U.S. Department of Energy and the Washington State Department of Ecology, with concurrence by the U.S. Environmental Protection Agency.

10/22/99
Date

Keith A. Klein
Manager, Richland Operations
U.S. Department of Energy

Signature sheet for the Record of Decision for the U.S. Department of Energy Hanford 100-HR-3 Operable Unit interim remedial action between the U.S. Department of Energy and the Washington State Department of Ecology, with concurrence by the U.S. Environmental Protection Agency.

for Chuck C. Clarke
Regional Administrator, Region 10
U.S. Environmental Protection Agency

10-24-99
Date

Signature sheet for the Record of Decision for the U.S. Department of Energy Hanford 100-HR-3 Operable Unit interim remedial action between the U.S. Department of Energy and the Washington State Department of Ecology, with concurrence by the U.S. Environmental Protection Agency.

Michael A. Wilson
Program Manager, Nuclear and Mixed Waste Program
Washington State Department of Ecology

10/25/99
Date

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DECISION SUMMARY

U.S. Department of Energy Hanford Site 100-HR-3 Operable Unit Record of Decision Amendment

I. INTRODUCTION

This document presents an amendment to the Record of Decision (ROD) for the 100-HR-3 Groundwater Operable Unit at the Hanford Site. A recently discovered chromium plume adjacent to the Columbia River in the southwest corner of the 100-D Area is not within the current treatment zone of the pump and treat remedial action (Figure 1). Chromium concentrations in this groundwater plume are above regulatory standards for aquatic receptors.

Site Name and Location

USDOE Hanford 100 Area EPA ID# WA3890090076
U.S. Department of Energy
Hanford Site – 100 Area
Benton County, Washington

Lead and Support Agencies

The lead regulatory agency for this action is the Washington State Department of Ecology (Ecology). The U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) both concur with the need and justification for treatment of chromium contamination in groundwater under the southwest portion of the 100-D Area using a new innovative technology (In Situ Redox Manipulation [ISRM]). Ecology, EPA, and DOE participated jointly in the decision and the preparation of this document.

Statutory Citation for a Record of Decision Amendment

Ecology, EPA, and DOE signed the Interim Remedial Action ROD in April 1996. The *National Oil and Hazardous Pollution Contingency Plan* (NCP), 40 Code of Federal Regulations (CFR) 300.435(c)(2), provides for addressing and documenting changes to the selected remedy after issuance of a ROD. This ROD Amendment documents the selection of a new innovative technology for the treatment of the recently characterized plume in the southwest portion of the 100-D Area. Public participation and documentation procedures have been followed as specified at 40 CFR 300.435(c)(2)(ii).

Figure 1. Location of the 100-HR-3 Operable Unit.

Need for the Record of Decision Amendment

This Amendment is necessary to select a new remedy that may be more effective than the pump and treat-based remedy selected in the 1996 ROD. Implementation of the remedy will reduce the discharge of chromium-contaminated groundwater to the Columbia River, thereby reducing risks to aquatic organisms that are vulnerable to the toxic effects of hexavalent chromium. The recently characterized 100-D Area plume (100-HR-3 Operable Unit) contains high hexavalent chromium concentrations (Figure 2) above water quality criteria for aquatic receptors. This is an interim remedial action to protect the Columbia River by preventing toxic levels of hexavalent chromium in groundwater from reaching the river. This interim remedial action is not intended to be a final cleanup action for the aquifer.

Public Involvement

Notice of the public comment period and availability of documents for review was published in the *Tri-City Herald* on July 21, 1999. In addition, a fact sheet that summarized the Proposed Plan was mailed to approximately 1,200 people who have identified themselves as highly interested in the Hanford cleanup. The mailing list included local and regional government officials, members of the Hanford Advisory Board (a citizen/stakeholder cleanup advisory board), Tribal Nations with reserved treaty rights to Hanford-related resources, Natural Resource Trustees, and interested public. The Proposed Plan and fact sheet were placed in the four regional DOE information repositories and in the Administrative Record.

A public comment period was held from July 23 through August 23, 1999. Fact sheets and the Proposed Plan were mailed to a number of individuals in response to requests made during the comment period. The Proposed Plan and focus sheets identified that a public meeting would be held upon request. No public meetings were requested during the public comment period, therefore, none were held. A response to the comments received during the public comment period is included in the Responsiveness Summary, which is included as Appendix A to this ROD Amendment.

This ROD Amendment presents the selected interim remedial action for the newly characterized chromium plume at the 100-HR-3 Operable Unit. The selected interim remedy is chosen in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA), and to the extent practicable, the NCP. The decision to amend the 100-HR-3 ROD is based on the Administrative Record. This ROD Amendment is part of DOE's Administrative Record file. The locations of DOE's Administrative Record and information repositories are listed below.

Figure 2. Location of Chromium Contamination.

Administrative Record

ADMINISTRATIVE RECORD (contains all project documents)

U.S. Department of Energy
Richland Operations Office
Administrative Record Center
740 Stevens Center
Richland, Washington 99352

INFORMATION REPOSITORIES (contain limited documentation)

University of Washington
Suzzallo Library
Government Publications Room
Box 3529000
Seattle, Washington 98195

Gonzaga University
Foley Center
E. 502 Boone
Spokane, Washington 99258

Portland State University
Branford Price Millar Library
Science and Engineering Floor
SW Harrison and Park
P.O. Box 1151
Portland, Oregon 97207

DOE Richland Public Reading Room
Washington State University, Tri-Cities
Consolidated Information Center, Room 101L
P.O. Box 99, MSIN H2-53
Richland, Washington 99352

II. SITE HISTORY

The 100-HR-3 Operable Unit is located in the north-central part of the Hanford Site along the Columbia River (Figure 1). This operable unit includes groundwater underlying source operable units associated with the 100-D/DR and 100-H Reactor areas and the area between the two sites. During operation of the 100-D/DR Reactors from 1944 to 1967, large volumes of water were pumped from the Columbia River to cool the reactors. Sodium dichromate was added to the cooling water to inhibit corrosion of the reactor piping and leaked into the soil, contaminating the groundwater.

Contaminated groundwater entering the Columbia River poses a risk to aquatic organisms in the river. Most of the chromium found in the groundwater is in the form of hexavalent chromium. Groundwater in the area west of the 100-D/DR Reactors is approximately 24 m below the ground surface. The contaminated portion of the groundwater aquifer is approximately 5 m thick. Groundwater enters the Columbia River through upwelling in the river bottom and along seeps at the shoreline. Chromium concentrations in groundwater at the proposed ISRM site exceed 2,000 µg/L. The relevant standard for protection of freshwater aquatic life selected in the 1996 ROD was 11 µg/L (the Washington State ambient water quality standard).

Potential current and future risks to human and ecological receptors were evaluated in a qualitative risk assessment for the 100-HR-3 Operable Unit. The results of the risk assessment were as follows:

1. Human risks - Under current conditions, there were no unacceptable human health risks from groundwater contaminants because exposure is precluded by DOE site controls.

2. Ecological risks - Concentrations exceeded the Washington State water quality criteria (i.e., 11 µg/L) for protection of freshwater aquatic life for chromium, indicating that chromium poses potential risk to ecological receptors. Of particular concern is the potential for chromium-contaminated groundwater to enter pore water in the gravel river bottom, which is inhabited by salmon eggs, alevin, and fry.

3. Radiological risks - Calculations indicated that no aquatic or riparian organism will receive dose from the radionuclides in excess of the DOE Order 5400.5 limit of 1 rad/day.

The chromium concentrations in the newly investigated plume (west of the 100-D/DR Reactors) exceed concentrations used to identify the above risks. Therefore, the new chromium plume may present an endangerment to sensitive ecological receptors if not addressed by implementing the response action selected in the ROD Amendment.

An Interim Remedial Action ROD for the 100-HR-3 Operable Unit was issued in April 1996. The selected remedial action was use of pump and treat systems at the 100-D/DR and 100-H Reactor areas. The remedial action objectives for the 1996 ROD and for this ROD Amendment are as follows:

- Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River
- Protect human health by preventing exposure to contaminants in the groundwater
- Provide information that will lead to a final remedy.

During pore water and near-shore aquifer sampling activities in November 1995, elevated chromium concentrations were detected along the 100-D Area shoreline west of the current 100-D Area pump and treat system. Additional sampling at a characterization borehole drilled inland in 1996 showed a chromium concentration of greater than 1,000 µg/L. Four additional plume characterization boreholes were drilled in 1997 and revealed chromium concentrations exceeding 2,000 µg/L. Finally, in fiscal year 1999 the extent of the recently characterized chromium plume was more fully delineated through the installation of 12 more characterization boreholes. It was determined that this plume was not within the current capture zone of 100-D Area pump and treat system. This contaminant plume contains the highest chromium concentrations on the Hanford Site (Figure 2) known to date.

In 1997, a treatability test was implemented at this site to evaluate the feasibility of using the ISRM technology to treat the hexavalent chromium plume. The treatability test was successfully completed in 1999. Based on the positive results from this study and additional benefits associated with this technology, a full-scale use of the ISRM technology will be deployed to intercept the chromium "hot spot" plume.

III. REMEDY SELECTED IN THE 1996 INTERIM REMEDIAL ACTION RECORD OF DECISION

The selected remedy identified in the 1996 Interim Remedial Action ROD for the 100-HR-3 Groundwater Operable Unit is the pump and treat technology. One treatment system is currently in operation and removes chromium-contaminated groundwater at a rate of about 303 L/min and 284 L/min from the 100-D Area and the 100-H Area pump and treat systems, respectively. Two extraction wells are used at the 100-D Area, and five extraction wells are used at the 100-H Area.

Design and installation of the groundwater pump and treat systems was implemented in accordance with the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (RDR/RAWP) (DOE/RL-99-51), which was approved by EPA and Ecology.

The pump and treat extraction wells are located along the Columbia River near the 100-H and 100-D Reactor areas (Figure 1). Injection wells are located inland and upgradient from the 100-H Area extraction wells. The 100-H Area injection wells return treated groundwater to the aquifer. The treatment goal is to reduce effluent chromium concentrations to the maximum extent practicable; however, treated groundwater above 50 µg/L chromium will not be discharged in the injection wells.

The pump and treat systems were installed and began operations in 1997. As of May 1999, nearly 550 million L of groundwater have been treated, removing approximately 60 kg of chromium. Groundwater treatment by pump and treat will continue at the 100-HR-3 Operable Unit as described in the 1996 Interim Remedial Action ROD.

The point of concern for exposure of aquatic receptors is within the river substrate at depths up to 46 cm, where embryonic salmon could be present during part of the year. Because it is impractical to routinely monitor chromium concentrations at aquatic receptor exposure points, onshore monitoring of groundwater near the river has been used to assess the effectiveness of the treatment. Based on a preliminary dilution factor of 1:1 between the compliance wells and the river, a remediation goal of 22 µg/L was established (i.e., a 22 µg/L hexavalent chromium concentration in near-river compliance monitoring wells is considered to be equivalent to 11 µg/L at the location of the aquatic receptors).

IV. REMEDY SELECTED IN ROD AMENDMENT

The ISRM technology used during the treatability tests has been selected as the remedy for treatment of the newly discovered chromium plume in the southwest portion of the 100-D Area (Figure 2). Other innovative treatment technologies will continue to be evaluated for final cleanup of this operable unit. The use of ISRM technology will not affect ongoing operations of the 100-D and 100-H Area pump and treat systems.

The ISRM technology involves creating a permeable subsurface treatment zone to reduce mobile chromium in groundwater to an insoluble form. This is accomplished through the injection of sodium dithionite into the aquifer through a series of wells. Several days after injection of the sodium dithionite, unreacted reagent and reaction products are removed from the aquifer by extracting groundwater from the injection wells. The sodium dithionite reduces ferric iron to ferrous iron within the aquifer sediments, producing a reducing-type environment. Under these conditions, hexavalent chromium precipitates from solution as trivalent chromium. Trivalent chromium is not toxic or mobile. In this way, hexavalent chromium-contaminated groundwater flowing through the treatment zone will be treated to the less-toxic trivalent form.

During this process, dissolved oxygen levels are also reduced. Treatability studies at the site indicate that the groundwater is reoxygenated to 75% to 95% of the original levels before discharging to the Columbia River. Recuperation of oxygen levels is further enhanced by dynamic mixing in the river bottom. In addition, a brief exceedance of the secondary water standard for sulfate is anticipated as a result of chemical injection; however, groundwater is expected to meet the sulfate standard following withdrawal of the chemicals, which occurs within a few days of injection. ISRM implementation and performance monitoring will be described in the RDR/RAWP, including contingencies.

V. ELEMENTS OF REMEDY SELECTED

A series of injection wells will be used to form the permeable barrier and thereby intercept the chromium-contaminated groundwater. The RDR/RAWP will contain specific design details for the barrier. The following are the elements that comprise the selected remedy for this ROD Amendment:

- The barrier will approximately parallel the Columbia River but may also contain other orientations depending on the distribution of the chromium contaminant plume.

- The treatment barrier will be designed in accordance with the RDR/RAWP to attain the remedial action objectives identified in this ROD Amendment for this plume. Injection wells shall form a continuous treatment zone. The location, spacing, and overlap will be established in the RDR/RAWP. Based on recent treatability and numerical modeling studies, the initial injection well spacing is anticipated to be approximately 10.5 to 12.5 m apart. Hydrogeologic and chemical field parameters shall be monitored during installation of the treatment barrier to optimize emplacement process and barrier design.

- The treatment zone shall treat the chromium plume to 20 µg/L or less at each compliance well to achieve 10 µg/L at the river using the preliminary dilution factor of 1:1.

- Compliance monitoring wells will monitor chromium and dissolved oxygen concentrations between the injection wells and the Columbia River to determine the effectiveness of the treatment zone.

- Performance monitoring wells will measure other field parameters including sulfate, dissolved oxygen, pH, temperature, and specific conductance.

- The siting, design, and sampling of the compliance monitoring wells shall be adequate to define the boundaries of the plume, the effectiveness of the treatment zone, and shall be capable of assessing if barrier "breakthrough" occurs. This requires wells located both between the treatment barrier and the Columbia River and wells beyond the end of the treatment barrier to ensure compliance with the remedial action objectives.

- The installation of the treatment barrier shall be initiated within 15 months after signing the ROD Amendment and fully implemented by the end of fiscal year 2002, based on current knowledge of the plume and implementability of the treatment technology. Design and schedule will be implemented in accordance with the RDR/RAWP.

- If barrier breakthrough is identified, Ecology and EPA will determine alternative action to be taken.

- The first pore volume of purgewater generated during post-treatment extraction shall be disposed at the ModuTanks (*Resource Conservation and Recovery Act* [RCRA] interim status unit) and/or at the Effluent Treatment Facility (RCRA final status unit), both of which are located in the 200 Areas. Management of waste at these facilities will comply with all applicable RCRA requirements, including permit requirements. One pore volume is approximately equal to the volume of liquid injected in a treatment well. Subsequent withdrawn volumes will be disposed to the ground. The rationale for disposing the first pore volume to a RCRA-permitted facility is as follows: The Hanford purgewater discharge criterion for disposal to the ground for sulfate is 2,500 ppm (*Strategy for Handling and Disposing of Purgewater at the Hanford Site*, WHC-MR-0039, 1990). Experience has shown that the withdrawn water from the ISRM process is likely to exceed this criterion until after one pore (injection) volume has been withdrawn. Therefore, it is necessary to collect the first pore volume and send it for treatment and disposal to a ModuTank or Effluent Treatment Facility. The first pore volume also contains about 75% of the recovered sulfate. The remaining pore volumes are generally less than the discharge criteria, so they can be disposed to the ground. The withdrawn water will be analyzed for sulfate to confirm that it meets discharge criteria before discharging it to the ground.

- Institutional controls for protection of human health required by the 1996 ROD are unchanged.

- Applicable or Relevant and Appropriate Requirements (ARARs) set forth in the 1996 ROD are unchanged with the exception of WAC 173-218 and 40 CFR 144, Subpart B, which are not ARARs for this ROD Amendment.

  The Underground Injection Control regulations in WAC 173-218 and 40 CFR 144, Subpart B prohibit the use of an injection well that may result in a violation of any primary drinking water standard or that may otherwise adversely affect beneficial use of groundwater. The solution being injected does not contain any constituents with a primary drinking water standard, and beneficial use of the groundwater will not be affected. However, the groundwater will exceed the sulfate secondary drinking water standard for a brief period of time following injection. WAC 173-218 prohibits certain discharges to groundwater; however, this regulation specifically excludes cleanup actions undertaken pursuant to CERCLA.

  Water Quality Standards for Waters of the State of Washington (WAC 173-201A-040) for hexavalent chromium are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River. The chronic ambient water quality standard has been revised as of November 1997 from 11 μg/L to 10 μg/L.

- All hazardous substances, pollutants, or contaminants removed offsite, pursuant to the ROD, for treatment, storage, or disposal shall be treated, stored, or disposed of at a facility in compliance, as determined by EPA in Section 121(d)(3) of CERCLA and

40 CFR 300.440. Regional offices will provide information on the acceptability of a facility under Section 121(d)(3) of CERCLA and 40 CFR 300.440.

Current studies indicate that the treatment barrier will remain effective for approximately 20 years. After that time, the treatment barrier would become less effective in remediating the contaminated groundwater. Performance monitoring will be performed to track chemical trends in the compliance wells to evaluate the effectiveness of the barrier. Chemicals could be reinjected to reestablish the barrier.

During implementation of the ISRM technology, an annual report will be prepared by DOE for submittal to EPA and Ecology. The report will document the effectiveness of the technology in remediating the chromium plume. The contents of the annual report will be outlined in the RDR/RAWP.

VI. EVALUATION OF THE ALTERNATIVES

The NCP establishes nine criteria for evaluating remedial action alternatives. These criteria are divided into three categories of weighted importance, which include threshold, balancing, and modifying criteria. All remedies must meet the threshold criteria to be considered. The seven balancing and modifying criteria help describe relative differences between the alternatives. An evaluation of the alternatives by the nine evaluation criteria is required by CERCLA. The two alternatives evaluated were pump and treat and ISRM. The no action alternative was not evaluated in this ROD Amendment because it was evaluated in the 1996 ROD.

Because this remedy may result in hazardous substances remaining onsite above levels that allow for unlimited use, a review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within 5 years after the commencement of the remedial action. This is an Interim Action ROD; therefore, review of this site and this remedy will be ongoing as the Tri-Parties continue to develop final remedial measures for the 100 Area National Priorities List site.

Threshold Criteria

1. Overall Protection of Human Health and the Environment

Because institutional controls were established in the 1996 Interim Remedial Action ROD, human health is protected under both alternatives. Both the ISRM and pump and treat alternatives would provide overall protection of human health and the environment by reducing chromium concentrations and exposure to ecological receptors.

2. Compliance with Applicable or Relevant and Appropriate Requirements

Both the ISRM and pump and treat alternatives will attain all ARARs.

Balancing Criteria

3. Long-Term Effectiveness and Permanence

The ISRM technology better achieves long-term effectiveness when compared to the pump and treat technology for the following reasons:

- The ISRM technology converts chromium to a chemically stable and less toxic form (trivalent chromium).
- The ISRM is a passive treatment system that works continuously, whereas the pump and treat remedy requires a continuous operation and maintenance process to remain effective.
- The treatment barrier is expected to last approximately 20 years without additional maintenance. In contrast, the pump and treat remedy has a 10-year design life, and components may need to be replaced as they wear out.
- The ISRM treatment barrier can be reestablished, if necessary, by injecting additional treatment chemicals in the aquifer.

4. Reduction of Toxicity, Mobility, or Volume Through Treatment

The ISRM process reduces the toxicity, mobility, and volume of chromium in the groundwater. The pump and treat process removes and reduces mobility of contaminants from the aquifer; however, the toxicity of the chromium remaining in the groundwater is not reduced.

5. Short-Term Effectiveness

The ISRM and pump and treat alternatives both meet the criterion of short-term effectiveness. For ISRM it will take about 2 years after establishing the barrier for treated groundwater to reach the Columbia River. This is based on a groundwater flow rate of 0.3 m/day (1 ft/day). Pump and treat can establish hydraulic control soon after startup. However, chromium-contaminated groundwater between the Columbia River and the hydraulic capture zone (pump and treat) or the treatment barrier (ISRM) would not be impacted initially after implementing either alternative. Concentrations in excess of 20 μg/L may be observed in the compliance wells during the early stages of ISRM deployment.

Short-term risk to workers will be slightly higher with the ISRM alternative as a result of installation of additional wells and the process of injecting and removing treatment chemicals. Well installation and injection/withdrawal processes present an increased potential for environmental impact. Neither the pump and treat nor the ISRM alternative is expected to present any significant increased risk to the community.

6. Implementability

Both alternatives are implementable. The pump and treat is well established. Although the ISRM is an innovative technology, field-scale testing has proven it to be easily implementable.

Implementation of either of the two remedial alternatives would include close coordination with state and federal resource agencies, Tribal Nations, and Natural Resource Trustees to avoid or minimize further impacts to ecological receptors while conducting remedial activities.

7. Cost

Net present-worth values for both options are presented in Table 1. A definitive cost estimate for the preferred alternative will be prepared as part of the remedial design.

Table 1. Remediation Cost Comparison[a].

	ISRM[b]	Pump and treat[b]
Capital $	$3,920,000	$ 1,750,000
Annual Operation and Maintenance	$ 50,000	$ 785,000
Net Present Value[c] (5-year period)	$4,136,000	$ 5,264,000
Net Present Value[c] (10-year period)	$4,330,000	$ 8,180,000
Net Present Value[c] (20-year period)	$4,612,000	$12,610,000

[a]Cost estimates have been updated to incorporate discount and inflation rates and to correct erroneous cost values reported in the Proposed Plan. The cost difference between those shown in the proposed plan and in the ROD Amendment do not exceed the estimated range for CERCLA cost estimates.

[b]Cost estimate +50% to –30%.

[c]Based on discount rate of 3.8% and inflation rate of 2.7% for outyears.

Modifying Criteria

8. State Acceptance

The State of Washington concurs with the preferred alternative.

9. Community Acceptance

Appendix A of this ROD Amendment is a responsiveness summary to comments received during the 30-day public comment. As a result of public comment, the preferred alternative identified in the Proposed Plan is the selected remedy in this ROD Amendment.

VII. STATUTORY DETERMINATIONS

The selected remedy is deployment of the ISRM technology at the recently characterized chromium plume in the 100-D Area, as described above in Section IV. Under CERCLA Section 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous waste as a principal element and bias against offsite disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

Ecology and EPA believe that the amended interim remedy (use of the ISRM technology) is protective of human health and the environment. Treatability studies have demonstrated that this technology is effective with minimal risk to workers. Site institutional controls will continue during the interim remedial action period that will limit human access to the groundwater. Ecological risk will be addressed by the amended interim action by reducing concentrations of chromium to ambient water quality standards within the river-bottom substrate. A compliance monitoring plan will be developed and implemented to assess barrier performance. If barrier breakthrough is identified, Ecology and EPA will determine alternative action to be taken.

Compliance with Applicable or Relevant and Appropriate Requirements

The ISRM technology complies with federal and state requirements that are applicable, relevant, and appropriate. The ARARs set forth in the 1996 Interim Remedial Action ROD for the 100-HR-3 Operable Unit will not change with the exception of WAC 173-218 and 40 CFR 144, Subpart B, which are not ARARs for this ROD Amendment.

The Underground Injection Control regulations in WAC 173-218 and 40 CFR 144, Subpart B prohibit the use of an injection well that may result in a violation of any primary drinking water standard or that may otherwise adversely affect beneficial use of groundwater. The solution being injected does not contain any constituents with a primary drinking water standard and beneficial use of the groundwater will not be affected. However, the groundwater will exceed the sulfate secondary drinking water standard for a brief period of time following injection. WAC 173-218 prohibits certain discharges to groundwater;

however, this regulation specifically excludes cleanup actions undertaken pursuant to CERCLA.

Water Quality Standards for Waters of the State of Washington, (WAC 173-201A-040) for hexavalent chromium are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River. The chronic ambient water quality standard has been revised as of November 1997 from 11 µg/L to 10 µg/L.

Cost Effectiveness

In the Tri-Parties judgement, the selected remedy is cost-effective, with costs that are proportional to the overall effectiveness.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The amended interim action would use permanent solutions to the maximum extent practicable and is an innovative technology.

Preference for Treatment as a Principal Element

Because the amended interim action would treat chromium contamination in the groundwater, this remedy would meet the statutory preference for use as a remedy that involves treatment as a principal element.

VIII. DOCUMENTATION OF SIGNIFICANT CHANGES FROM THE PREFERRED ALTERNATIVE IN THE PROPOSED PLAN

There have been no changes in the selected remedy from the preferred alternative in the Proposed Plan.

Appendix A

Responsiveness Summary Overview

Overview of responses and comments provided by the Department of Ecology on the *Proposed Plan for an Amendment of the Interim Action at the 100-HR-3 Operable Unit).*

The following responsiveness summary addresses public comments on the proposed plan for an amendment of the Interim Remedial Action at the 100-HR-3 Operable Unit. The public comment period on the proposed plan was held from July 23, 1999 to August 23, 1999. At the time the public comment period ended, there were no requests for a public meeting.

Ecology received five comments on the proposed plan. All five of the comments were submitted in writing. Three of the five public comments addressed more than one topic of concern; therefore, out of the five individual comments there were a total of 12 comments. Of these 12 comments, eight related directly to the proposed plan, and four did not. The comments generally fall into three categories. The following is a summary of the comments, and Ecology's response.

- Support: Two of the comments fully supported the application of the new technology.
- Off Topic: One set of comments did not pertain directly to the use of the new technology.
- Concerns: Two commentors raised the following seven concerns, which are addressed below.

Comment Summary and Response

1. **Comment:** "There is no known technology that will completely clean up contaminated groundwater."

   Ecology agrees. The application of this technology, however, is effective at altering toxic hexavalent chromium to less toxic trivalent chromium and precipitating it out of the groundwater. This technology is effective at treating the hexavalent chromium plume to concentrations that are protective of human health and the environment.

2. **Comment:** "Just like the traditional 'pump and treat' option, the Redox Manipulation process requires a dedicated pumping system for long-term chemical injection and extraction. That being so, the projected cost-savings appear tenuous and overstated."

   Ecology provides the following clarification. The chemical, sodium dithionite, is injected into the groundwater, allowed to react, and then withdrawn and properly disposed of, therefore, a dedicated pumping and treatment system is not required.

The resulting permeable barrier should not require any additional injections or extractions for about twenty years.

3. **Comment:** "Any In Situ Redox Manipulation development/demonstration/ deployment assistance given by Environmental Management's (EM's) Office of Science and Technology (OST), for the proposed remedial action, should be factored into any 20-year comparative cost-analysis.

   Ecology provides the following clarification. The OST funding was to develop the technology. DOE-Richland Operations Office will provide the funding to carry out the remedial action. Also, the cost comparison is between implementing Redox compared to operating a pump and treat system.

4. **Comment:** "Drilling even more treatment/sampling wells, as proposed, provides additional avenues for the migration of other Hanford contaminants to the riverine environment."

   Ecology provides the following clarification. The possibility of establishing migratory pathways was looked at closely. In the area of the plume there are no other contaminants present in the vadose zone. Furthermore, the hexavalent chromium contamination is found only in the upper-most aquifer or the unconfined aquifer. All of the wells will only be drilled to the base of this upper aquifer and no deeper. Therefore, the wells will not provide migration pathways to the deeper aquifers. The wells will be drilled according to WAC 173-160 in order to insure that they are installed correctly. If this technology were to be implemented in the 200 plateau areas then, yes, migratory pathways from the wells and cross-contamination would be a very important consideration.

5. **Comment:** "The longevity of the barrier was estimated from the sediment reduction rate that uses reducible iron content of the sediment as a basis. The reducible iron content (31.8±5.6 μmol/g) was calculated from results of column and batch studies performed on <4mm particle size fractions "of the entire field sediment" (Williams *et al.*, 1999 p.4.4). According to the average particle size distribution of the sediment, the calculated reducible iron content of the complete sample would be about 1/3 of the <4mm fraction (11.0±3.0 μmol/g), which was also stated in Willimas *et al.* (1999). Calculations made with reducible iron content measured for the <4mm particle size fraction overestimated the treatment capacity of the sediment, therefore the longevity of the ISRM treatment."

   Ecology provides the following clarification. The calculation of the barrier longevity of 171 pore volumes is correct (calculation shown below) and is based upon the total sediment reducible iron content of 11.0±3.0 μmol/g. The wording of the first sentence of the second paragraph in Section 4.3 (page 4.4) should be changed to avoid confusion between laboratory-scale (< 4 mm) and field-scale parameters.

   a) electron donor: moles of electrons per cm3 liquid from the Fe(II):11+/-3.0 umolFe^{2+}/g x 1 umol e-/umol Fe^{2+} x 2.3 g sed/cm^3 tot x cm^3tot/0.14 cm^3 liq x mol/10^6 μmol = 1.807 x 10^{-4} mol e-/cm^3 liquid assumptions: total sediment average reducible iron content field scale dry bulk density (2.3 g/cm^3) and porosity (0.14)

b) electron acceptors: moles of electrons per cm^3 liquid from dissolved oxygen and chromate: 8.3 mg/L O_2 x g/1000 mg x mol O2/32g x L/1000mL x 4 mol e-/molO_2 = 1.038x10^{-6} mol e-/cm^3 1.0 mg/L $HCrO_4$- x g/1000 mg x mol chromate/117g x L/1000mL x 3 mol e-/molCrO_4 = 2.5564x10^{-8} mol e-/cm^3 total electron acceptors: 1.038x10^{-6} + 2.5564x10^{-8} = 1.064 x 10^{-6} mol e-/cm^3

c) electron donors/electron acceptors = 169.9 pore volumes

This is a conservative estimate. Knowing the variability of the data, the change in the barrier longevity can be estimated. Dissolved oxygen is typically not saturated in the 100D area (or most ground water systems), and less oxygen (average 6.0 mg/L) flowing through the barrier will oxidize the barrier more slowly (it will last longer; 233 pore volumes). The 1.0 mg/L chromate has an insignificant effect (1%) on barrier oxidation relative to dissolved oxygen. The highest chromate level measured (2 mg/L) would lower the barrier longevity slightly (166 pore volumes). The most realistic case would be to assume an average chromate concentration, which would be much smaller than 1 mg/L. Again, these chromate concentrations have an insignificant effect on the barrier longevity.

Other electron acceptors, if reduced in this zone, would also contribute to oxidizing the barrier. Uranium (VI) species reduction by reduced iron has been studied and will occur. Because the U(VI) is present at small concentrations (10 ppb), however, there is extremely little impact on the barrier oxidation relative to chromate (which is small relative to dissolved oxygen).

6. **Comment:** "The study did not consider ion exchange reactions between absorbed Fe^{2+} and e.g. Mg^{2+}, which would mobilize available iron."

Ecology provides the following clarification. Bench-scale studies of the ISRM process have considered ion exchange. Evidence that Fe^{2+} is not mobilized during oxidation by ion exchange or any other process is based on: a) analyzing all of the metals in the liquid phase that may be mobilized during reduction and oxidation (laboratory column experiment with reduction and oxidation; ICP-MS analysis of liquid effluent samples), and b) solid phase iron extractions on the sediment that is untreated, reduced, and reduced/oxidized. The water used in column experiments discussed below approximated the major ions found in the Hanford aquifer (consisting of 15 mg/L NaCl, 8.2 mg/L KCl, 67 mg/L $CaSO_4$, 13 mg/L $MgCO_3$, 150 mg/L $CaCO_3$, 15.3 mg/L H_2SiO_3 and the pH adjusted to 7.7 to 8.2), so if Mg^{2+} injection into a reduced sediment column could cause Fe^{2+} mobility, it would be measured by Fe^{2+} in the effluent and iron loss from the sediment. Iron mobility was also measured during dithionite reduction, which was expected to be greater, because

Fe^{3+} phases are dissolved and reduced. Results showed a small amount of iron movement during reduction, but little during oxidation.

7. **Comment:** "The treatment longevity calculation assumes that hydrological and chemical conditions will remain stable during the life of the treatment, which is estimated to be 20-25 years. This assumption might not be valid as the result of the following processes:

7a.) Precipitation of the $Fe(OH)_3$ and $CR(OH)_3$ species as the result of the remediation process can reduce the availability of Fe^{2+} for further reactions. Furthermore, when additional dithionite is injected to reestablish the barrier, removal of $Cr(OH)_3$ species might be necessary to expose reaction surfaces."

Ecology provides the following clarification. Over the barrier lifetime, chromate is reduced and precipitated as the Fe^{2+} species are slowly oxidized by mainly dissolved oxygen and some by chromate. As demonstrated in a long term column experiment described in Williams and others (1999, Section 4.6), the $Cr(OH)_3$ remains immobile even in fully oxic systems, so there is a potential for coatings of precipitated minerals forming and remaining in the barrier zone. However, at the concentration of chromate being treated at the 100D Area, this effect is not large enough to significantly alter the functioning of the barrier. Assuming that 2 mg/L chromate (highest concentration observed in the 100-D Area) will be precipitating for 170 pore volumes (barrier lifetime of about 25 years), 0.34 mg of Cr^{3+} [0.67 mg $Cr(OH)_3$)] will have precipitated in 1 cm^3 of pore space. With a density of 5.21 g/cm^3 for $Cr(OH)_3$, 0.013% of pore space would now be occupied by $Cr(OH)_3$. This small amount would have an insignificant effect on changing the porosity or chemical properties of the barrier.

7b.) "During the 20-25 year life of the treatment system, hydrologic conditions of the area might change due to increasing temperatures in the region. In the next 100 years, a 4-5°F increase can be expected in the summer and winter average temperatures in the region according to estimates of the U.S. Global change research Program (USGCRP). Even a one degree average temperature elevation, that could be expected during the next 25 years, can moderately change the ground and surface water levels. The annual fluctuation of the groundwater level will be much higher, and groundwater flow rates can increase significantly during the winter flood periods."

Ecology provides the following clarification. The estimate of the lifetime of the barrier is just that, an estimate. In the absence of predictable future changes, it assumes that conditions will remain similar to the present. Any changes in groundwater flow will effect the lifetime of the barrier. Increased precipitation, or anything else that increases the groundwater flow, might decrease the expected life of the barrier. A drought, or anything else that decreases the flow will increase the lifetime of the barrier. However, the important point is how much contaminated water the barrier will treat. If water flows through the barrier more quickly, then it will be treated more quickly, thus nullifying the effect of the shorter barrier life.

Summary

Ecology supports the use of the new technology, In Situ Redox Manipulation, as described in the Proposed Plan for an Amendment of the Interim Remedial Action at the 100-HR-3 Operable Unit. The public is encouraged to continue to follow all Hanford clean-up efforts in the future. For more information about this or other Hanford related subjects, please call 1-800-321-2008.